A Multi-Modeling Approach to Forecasting Climate and Land Use Change Impacts on Fish Habitat Suitability in a Great Lakes Tributary

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Introduction

The Muskegon River Watershed:

- Supports valuable fisheries and habitat for salmonids and walleye in Lake Michigan.
- Watershed = 7,400 km^2; annual flows = 60 cms; Stable flows, groundwater dominated .
- Still in good shape!
- We conducted assessments and developed a multi-modeling framework to forecast potential futures given land use and climate change scenarios guided by stakeholder input.

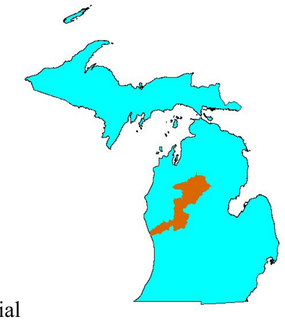
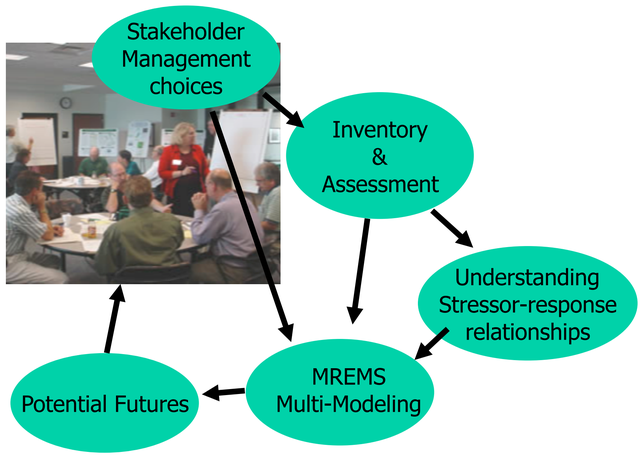
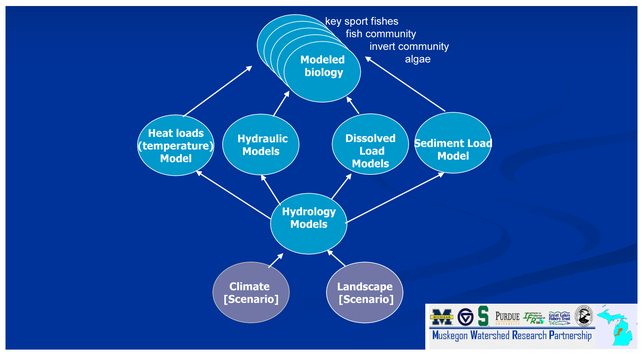


Figure 1. Muskegon River tributary to Lake Michigan.

Rationale and Science Behind Forecasts



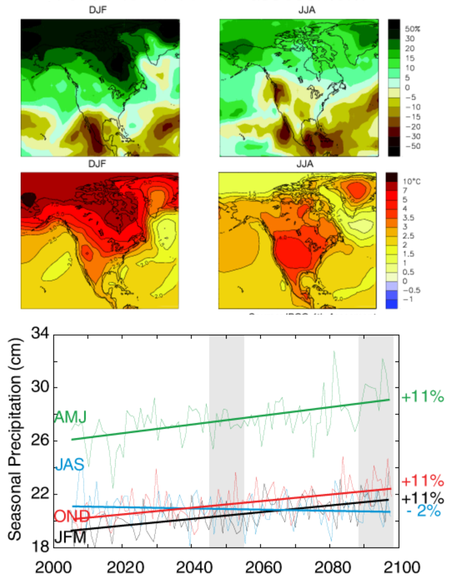
Stakeholder (MRWA, State Agencies, Local Gov. Units, NGOs, citizens) concerns for the watershed's future were identified and addressed during several meetings at the beginning, middle, and end of the assessment and modeling process. Primary stakeholder concerns were land use, climate change, dams, sediment, and water quality.



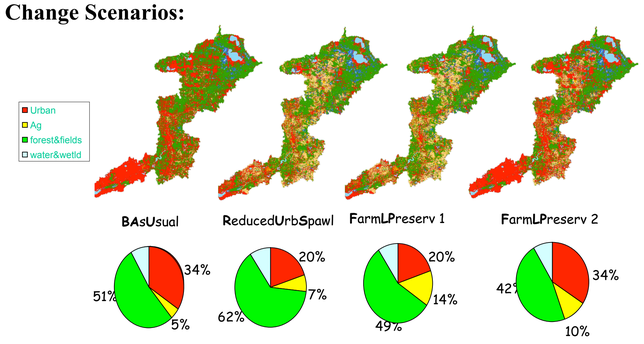
Ecological forecasts were provided by a multi-modeling framework (MREMS) for the Muskegon River Watershed by a partnership of modelers from MSU, UM, Purdue , NOAA, and Fisheries Projections, Inc.

Climate Change Scenarios from 4th IPCC Assessment predict warmer and wetter climates in Michigan. Temperature and precipitation were run through MSU's Integrated Landscape Hydrology Model (Hyndman and Kendall) to generate groundwater recharge rates and surface flows.

A1B, A2, B1 scenarios
from the 4th IPCC assessment

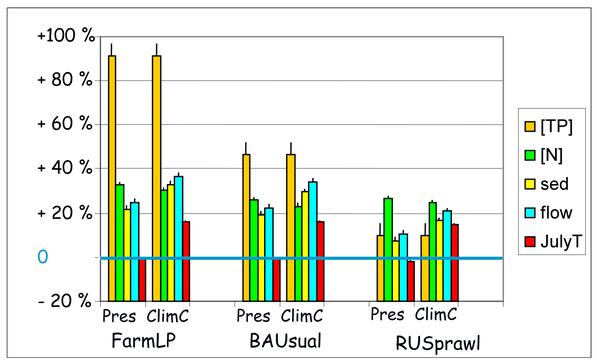


Land Use Change Scenarios:



Purdue's Land Transformation neural net Model (LTM2) generates future land use change scenarios.

River habitat response to land use and climate change across Muskegon basin. Impacts of climate change and land use change are lowest under reduced urban sprawl scenarios.



Climate is held constant for all land use scenarios, and scenarios are ordered in this figure by decreasing impact on physical channel variables. TP = average annual total phosphorus load; N = average annual dissolved inorganic nitrogen load; SED = sediment loads; July T = average July temperature. Changes imply a long-term trajectory relative to 1998 conditions.

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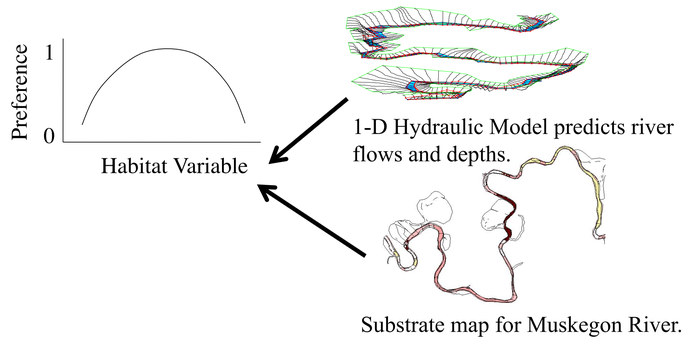
Dynamic Fish habitat Suitability Modeling

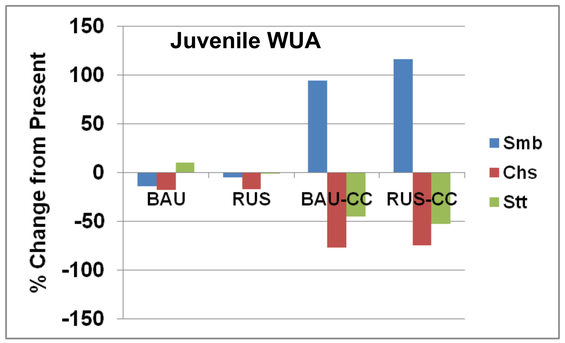


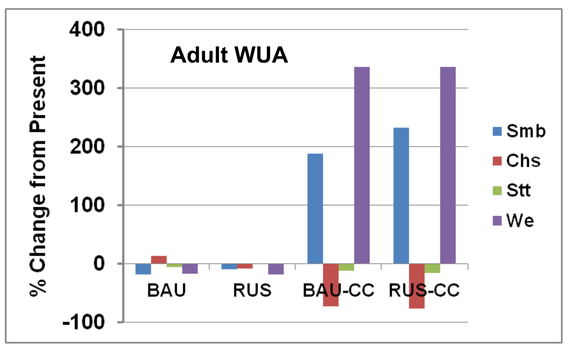
Dynamic Weighted Usable Area model (WUA) determines fish species habitat suitability for each day based on predicted temperature, depth, velocity, and substrate for each cell along each transect. WUA calculated as:

WUA = (Dpref * Vpref * Subpref * Temppref) * river area

Results

Climate change - adjusted land use scenarios had greater impacts on fish habitat suitability compared to land use change scenarios alone. Habitat for warm water species (smallmouth bass and walleye) increases greatly under climate change compared to coldwater species (salmon and steelhead).





Status - Wiley, M.J., et al. 2010. A multi-modeling approach to evaluating climate and land use change impacts in a Great Lakes River Basin. *Hydobiologia* 657:243-262.

Future work will run buffer and groundwater recharge protection scenarios for sub-watersheds to direct planning and restoration efforts, and expand modeling effort to other watersheds.